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The employment of Support Vector Machine to classify high and low performance archers based on bio-physiological variables

Zahari Taha¹, Rabi Muazu Musa^{1,2}, Anwar P P Abdul Majeed¹, Mohamad Razali Abdullah², Muhammad Amirul Abdullah¹, Mohd Hasnun Arif Hassan¹ and Zubair Khalil¹

¹Innovative Manufacturing, Mechatronics and Sports Laboratory, Faculty of Manufacturing Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia

²Faculty of Applied Social Sciences, Universiti Sultan Zainal Abidin, 21300 Kuala Terengganu, Terengganu, Malaysia

E-mail: anwarmajeed@imamslab.com

Abstract. The present study employs a machine learning algorithm namely support vector machine (SVM) to classify high and low potential archers from a collection of bio-physiological variables trained on different SVMs. 50 youth archers with the average age and standard deviation of (17.0 ± 0.56) gathered from various archery programmes completed a one end shooting score test. The bio-physiological variables namely resting heart rate, resting respiratory rate, resting diastolic blood pressure, resting systolic blood pressure, as well as calories intake, were measured prior to their shooting tests. k-means cluster analysis was applied to cluster the archers based on their scores on variables assessed. SVM models i.e. linear, quadratic and cubic kernel functions, were trained on the aforementioned variables. The k-means clustered the archers into high (HPA) and low potential archers (LPA), respectively. It was demonstrated that the linear SVM exhibited good accuracy with a classification accuracy of 94% in comparison the other tested models. The findings of this investigation can be valuable to coaches and sports managers to recognise high potential athletes from the selected bio-physiological variables examined.

1. Introduction

Research has indicated that archery sport involves conscious breathing adjustment and synchronization with arm actions [1]. Shooting process in the sport of archery has been described as the concurrent associations between breathing; gross motor control of body positioning; fine-motor control of the archer's fingers, joints, limbs, feet, and cheek; and the handling of perceptual cues related with the target, the sights and the peep or string [2].

Despite the evidence that archery is not perceived as a physically intensive compared to other sports such as basketball, rugby, cycling or soccer, yet, there is still a demand for the archers to take their nutritional status into account. For instance, it has been found that breakfast is an essential meal of the day. When an archer is planning for a practice or competition that could extend for a long time, he/she could deliver a better performance after taken a healthy breakfast [3]. Moreover, evidence has established that in the course of archery performance, an archer needs to have a high degree of



attention and relaxation, and as such there is need to consider a number of cardiac parameters such as resting heart rate, resting systolic blood pressure, resting diastolic blood pressure as well as the pulmonary parameters which comprise of resting respiratory rate [4]. The aforementioned physiological variables are important for influencing success in the sport of archery.

Recently, different types of machine learning techniques have been utilized for forecasting and classifying a diversity of human performance variables owing to its innate advantages against conventional means [5]. For example, artificial neural networks has been applied to predict energy expenditure [6] as well as to classify activity types [7]. Random forest classifier, in another perspective, has been employed to also classify activities from wrist-worn accelerometers [8] as well as classifying the playing positions of elite junior football players [9] amongst others. Nonetheless, the usage of Support Vector Machine (SVM) in classifying potential archers based on a number of bio-physiological performance variables has yet been revealed. Thus, this study aims at assessing the effectiveness of the preceding classifier in determining high and low potential archers.

2. Material and methods

2.1. Participants

50 archers were enlisted in this investigation. The archers consisted of 37 male and 13 female youth between the age's range of 13-20 with a mean, and standard deviation of (17.0 ± 0.56) gathered from various archery programme in Malaysia. The archery shooting test was completed prior to the previous fitness testing utilizing a simulated competition shooting area of 50 meters range. The archers were granted four trials shot before taking the final six arrows scores. Informed consent was obtained in accordance with the procedures of the Ethical Review Board of the University Sultan Zainal Abidin, Malaysia.

2.2. Nutritional assessment

The nutritional status of the archers was evaluated using their three days dietary re-call. To achieve this aim, the researcher developed a form containing columns for the dietary of three days and the column for a time the meal is consumed. The form contained the serving size of each meal taken. The archers were enlightened on how to measure the quantity of each meal taken to ensure the accuracy of the actual dietary intake. The researcher instructed the archers to fill the form whenever they take their meals and drinks. The data collected for all their dietary intake of three days (two-week days and a weekend) was assessed using a Nutritionist Pro software to determine their dietary status.

2.3. Resting Heart Rate, Diastolic and Systolic Blood Pressure Measurement

Resting heart rate (RHR), resting systolic blood pressure (RSBP) and resting diastolic blood pressure (RDBP) of the archers were evaluated using Omron automatic Blood Pressure Monitor Device (HEM-7120) which has been reported as a reliable tool for measuring the related parameters [10]. The all specified cardiac parameters were measured while the archers were in resting condition and sitting comfortably on a chair, the device is placed at the level of chest, and the arm strap was attached securely on the left arm of the archers after which the strap was inflated automatically by the device, and monitor displayed result of Blood pressure, pulse rate measurement was noted. All measurements were completed early in the morning prior to any exercises or warm up.

2.4. Resting Respiratory Rate Measurement

The resting respiratory rate (RRR) was measured while the archers were comfortably sitting on a chair in an erect position. The palpating the respiratory movements of archer's chest was assessed manually by a specialist therapist for a period of one minute. A stop watch was used for one-minute time setting to ensure that the reading was collected within one minute as suggested by the preceding researchers [11]. The assessments were conducted three times, and the maximum value was taken.

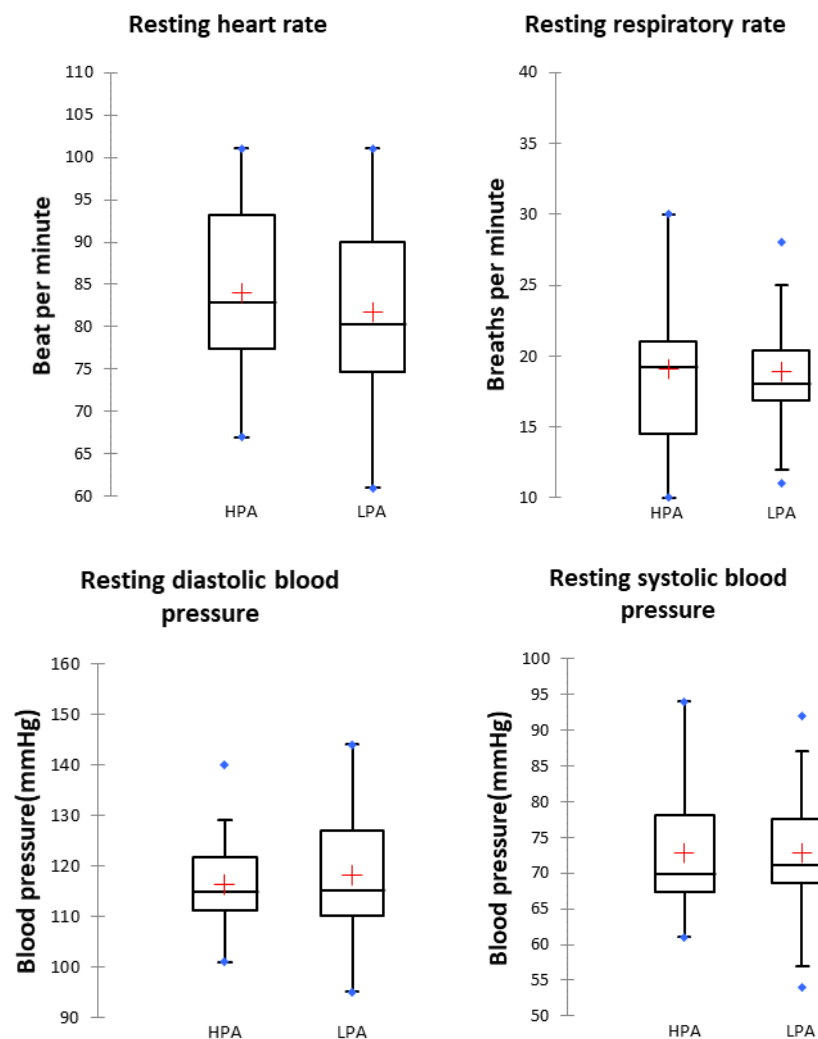
2.5. Data analysis

2.5.1. Clustering: k-means cluster analysis. The k-means clustering technique is employed to cluster the archers based on their performances in the selected variables and their shooting scores in which two classes, i.e. high potential archers (HPA), and low potential archers (LPA) are clustered.

2.5.2. Classification: Support Vector Machine. SVM is utilised to acquire the optimal hyperplane that could correctly classify the data into two distinct categories that are represented by HPA and LPA in the present study. Three different kernel functions are investigated namely fine, medium and coarse RBF. The scale of the fine, medium and coarse RBF is defined by $0.25 \cdot P^{0.5}$, $P^{0.5}$, $4 \cdot P^{0.5}$, respectively, where P is the number of predictors viz five. The fivefold cross-validation technique was employed in the present investigation [12]. The performance of the SVM models are evaluated through the classification accuracy (CA), sensitivity (SENS), specificity (SPEC), precision (PREC), error rate (ERR) as well as Matthew's correlation coefficient (MCC) of the aforesaid models.

3. Results and discussion

3.1. Clustering



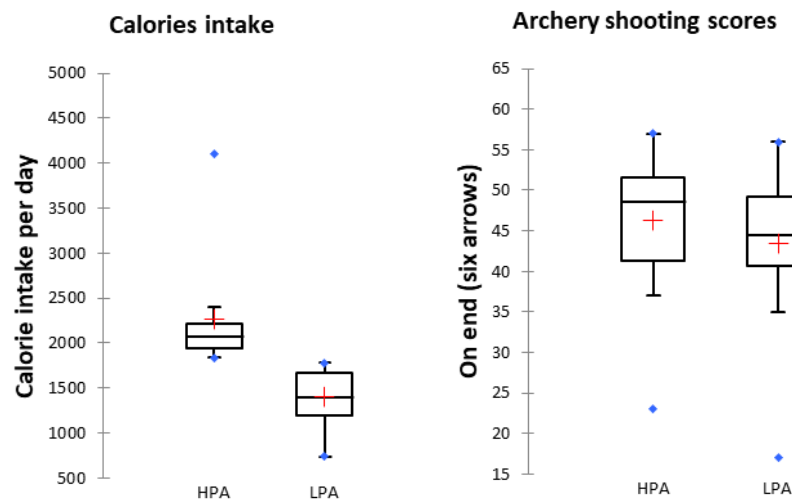


Figure 1. Comparisons of performance differences of the archers based on the evaluated bio-physiological variables.

The performance differences of the archers based on the six performance variables assessed that were clustered via *k*-means are shown in figure 1. It could be seen from the box plots that the mean performances of HPA are greater than LPA across all the five bio-physiological parameters measured in the study except for ‘resting diastolic blood pressure (RDBP)’. This observation is non-trivial as RDBP is should be inversely proportional towards performance. Therefore, the aforementioned variables are essential attributes that allow for an accurate discrimination between the HPA and LPA.

3.2. Classification

Table 1. Model evaluation.

SVM Models	ACC (%)	SENS (%)	SPEC (%)	PREC (%)	ERR (%)	MCC
Linear	94	88.89	96.88	94.12	6	0.8690
Quadratic	88	83.33	90.63	83.33	12	0.7396
Cubic	84	77.78	87.50	77.78	16	0.6528

It could be observed from table 1 that the linear SVM variation is able to produce exceptional classification accuracy of 94% through the evaluation of all assessment bio-physiological parameters. Furthermore, the model has a high MCC of 0.8690 which indicates the high correlation of the parameters assessed with respect to the classification of the HPA and LPA. The quadratic model on the other hand does provide a reasonably accurate classification of the archers with a CA of 88 %, whilst the cubic provides a CA of 84 %. It is evident through the present study although all models does provide good accuracy, nonetheless that the linear-based model provides the best classification for the purpose of talent identification for archers based on the predefined bio-physiological variables. The confusion matrix of the evaluated SVM models are illustrated in figure 2.

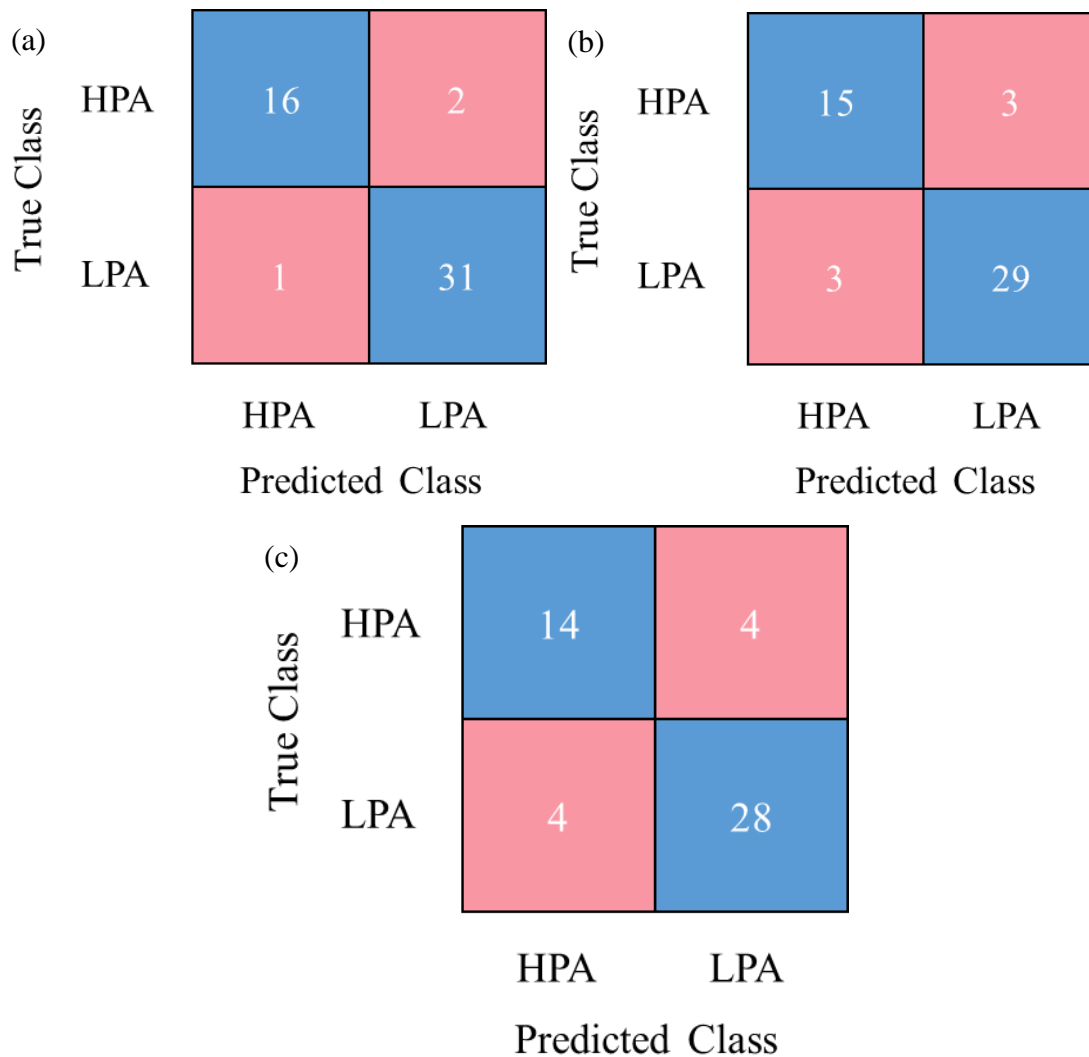


Figure 2. Confusion matrix (a) Linear; (b) Quadratic; (c) Cubic.

The present study has demonstrated that the selected bio-physiological variables examined can predict or classify reasonably the performance of the archers either as HPA or LPA. The shooting scores allow for the clustering of the archers with respect to measured bio-physiological variables. This was implemented via *k*-means as illustrated in the box plot (Figure 1).

It has been established from the investigation that nutrition is a vital component of archery performance. Since, sporting activity entails training and competition. The development of certain necessary variables such as skill, strength, power, speed, endurance, as well physical training could be accomplished when there is a good nutrition [13]. Furthermore, it was described that an archer has to consider optimum nutrition during both training and competition. If an archer plans on expending more than an hour shooting, it is recommended for him/her to have water, Gatorade, and refreshments with them [14]. It is equally essential to keep themselves “fueled” which can provide energy to the functioning muscle during shooting. An archer may become feeble and lose their vigour during competition due to the lack of eating. Moreover, an archer finishes shooting at the end of a long day; he/she may require eating an appropriate meal to refuel the body. Similarly, nutrition is likewise crucial in the pre, during, and post of the shooting process. Similarly, the present study to exemplify that resting heart rate, resting diastolic and systolic blood pressure could differentiate the performance level of the archers (see Figure 1).

The findings have also indicated that the capacity of lung function is integral to the archery performance. This discovery is consistent with the of the previous researchers who investigated the specific pulmonary parameter in all India inter-university archery competition and found that the capacity of lung function was high on all archers compare to normal men [4]. Moreover, it was inferred that the elite archers' respiratory frequency is higher as compared to that of novices and as such elite archers have a better and consistent performance during archery competition [15]. The present study shows the high, and medium performance archers have recorded higher levels of resting respiratory rate. The results explained further that the HPA have a good exhale control and autonomic balance which is essential for achieving optimum lung frequency during rest and in turn contribute to a better breathing control and postural stability during archery performance.

4. Conclusion

The present research has examined the impact of different bio-physiological variables in the effective performance of archery sport. It has been found from the study that a combination of bio-physiological variables specifically resting respiratory rate, calories intake and archery shooting scores could determine the grouping of the archer's performance. The study has also revealed that the utilisation of machine learning algorithms, in particular, the variation of SVM models is able to reasonably predict the class of the archers based on the chosen performance variables. In addition, the finding of this study could be useful to coaches and sports managers to identify the bio-physiological variables that influence the performance of the sport. Future study should consider other related performance variables correlated with the sport as well as other non-conventional classification techniques.

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